Advanced Liquid-Desiccant Technology

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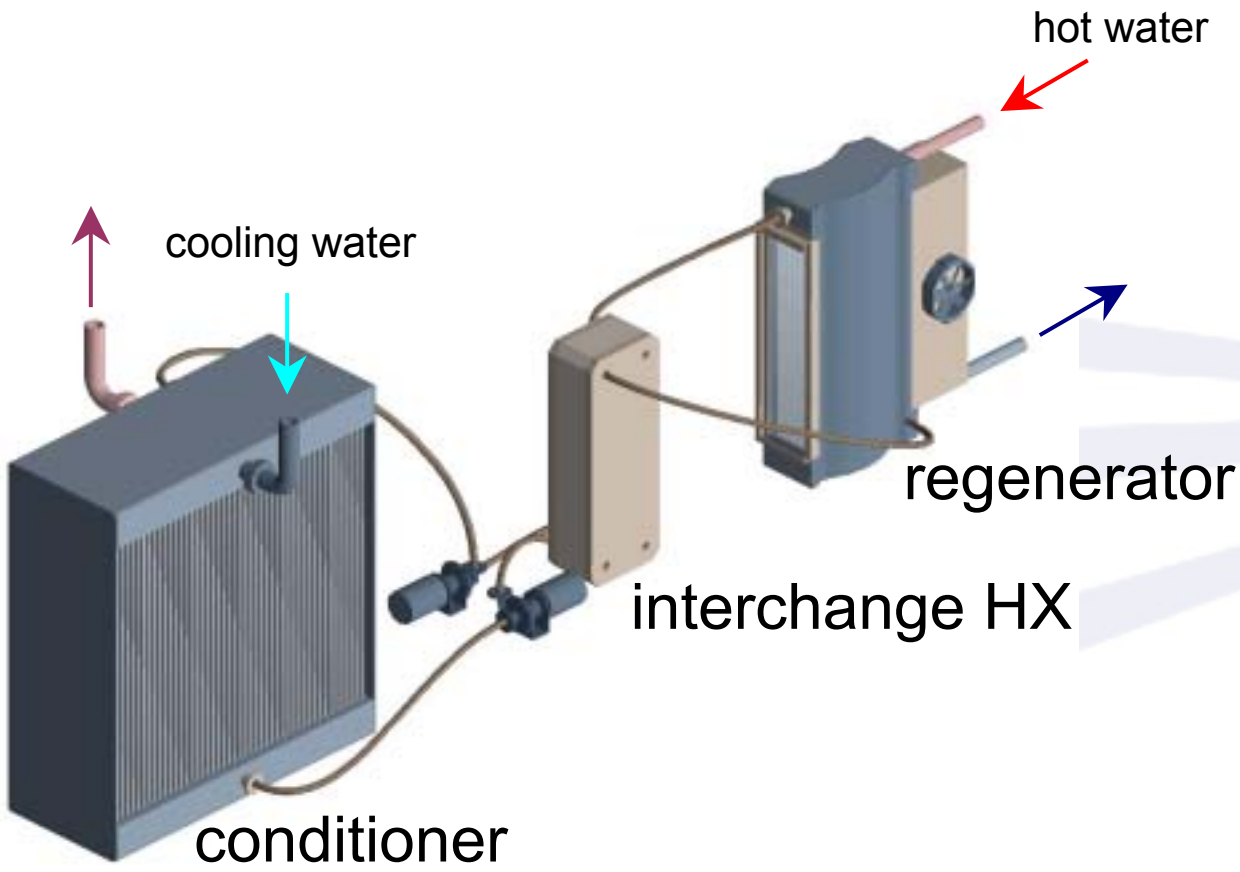
Overview

- Move liquid desiccant technology from industrial to HVAC applications
- Develop a new generation of liquid-desiccant conditioners and regenerators based on low-flow technology
- Package the new desiccant technology in a rooftop design that is familiar to the HVAC trade
- Address pervasive IAQ problems; increase ventilation while controlling humidity
- Add cooling to DE systems
- Simplify installation of DE systems

How Does a Liquid Desiccant Air Conditioner Work?



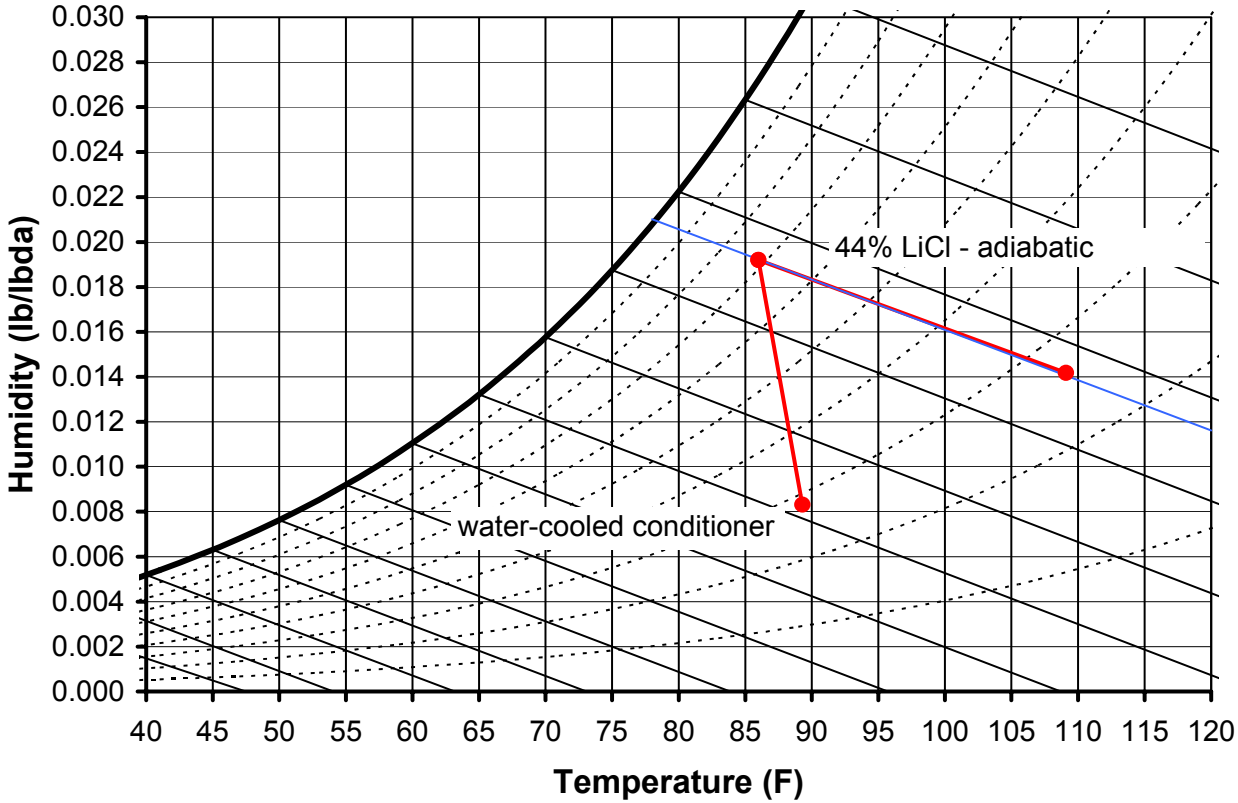
What advances have been made in liquid desiccant technology?

- **Very low flow rates of desiccant**
  - Flows reduced by factor of 10 to 50
  - No sprays or drip pans
  - Droplets completely suppressed
- **Continuous cooling of desiccant**
- **Wicking contact surface**
- **Plastic heat exchanger technology**

What Benefits do Liquid Desiccants Systems Provide?

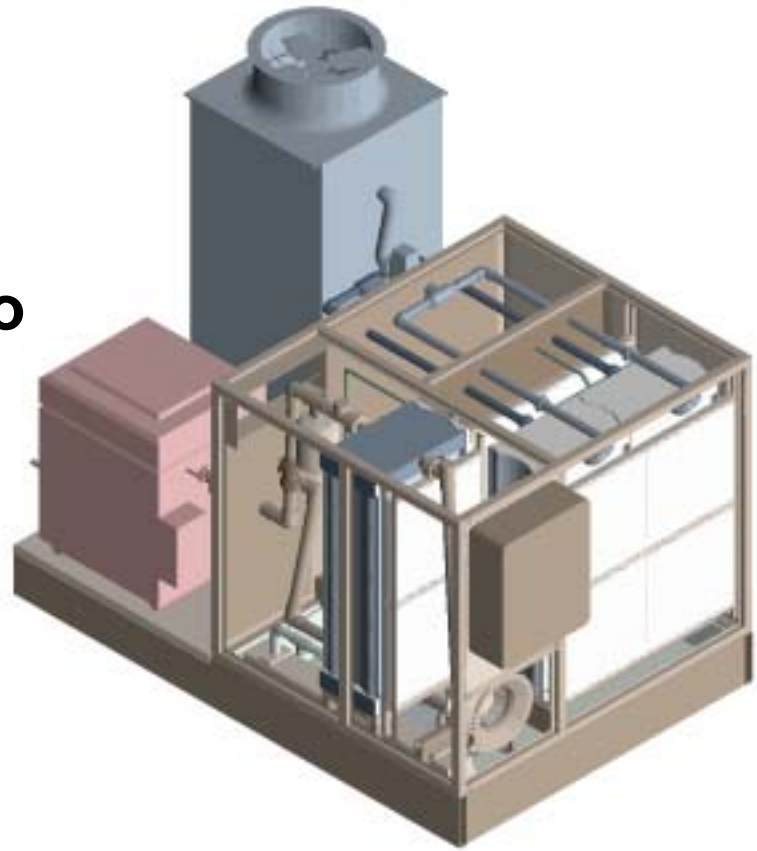
- **Excellent dehumidification**
  - Air does not have to be cooled below dewpoint
  - Can handle high ventilation loads
  - Dry cooling coils operating at higher temperatures
- **Heat and mass transfer in a single component**
  - low pressure drops
  - high “specific” cooling
  - Low surface area leads to small size
- **Low heat “dump back”**
- **Good COP at low regeneration temperatures**
  - 0.54 COP at 160 F
- **Potential for low first cost and operating costs**

A Liquid Desiccant Conditioner both Dries and Cools



AILR OA-6000

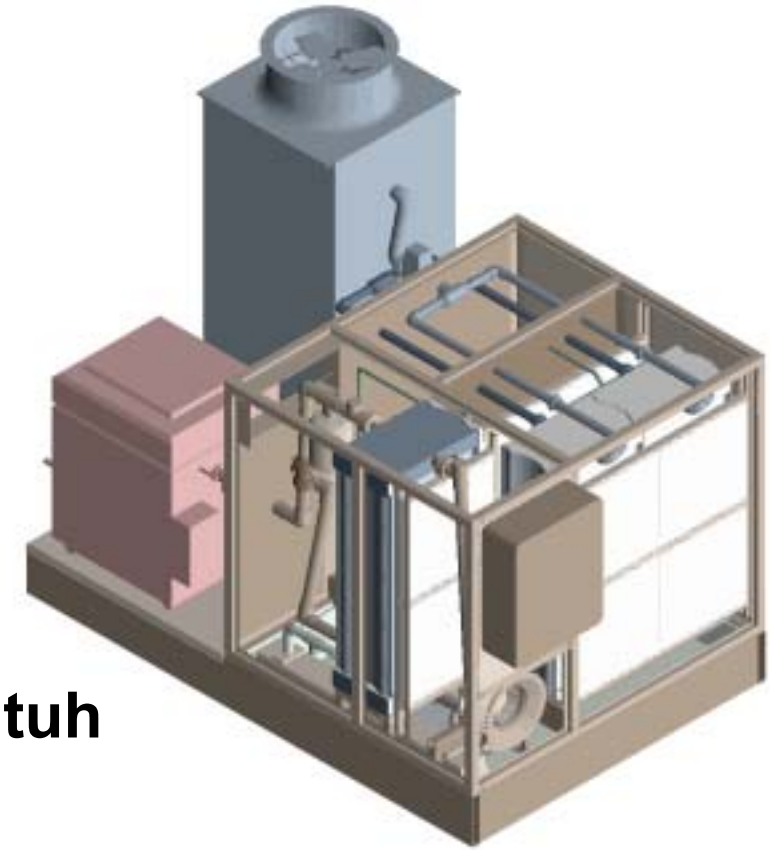
- Components developed with NREL support
- Design funded by ORNL
- Roof-top air conditioner
- Low-flow technology for zero desiccant carryover
- 6,000 cfm; 100% outdoor air
- Almost 100% latent cooling
- 250 lb/h water removal
- Avoids overcooling/reheat



AIL Research, Inc.

Engineering Specifications

- Process Air Flow: 6000 cfm
- Tower Water: 75 gpm
- Tower Air Flow: 6200 cfm
- Tower Make Up: 1.0 gpm
- Desiccant: LiCl
- Desiccant Flow: 5 gpm
- Regen Air Flow: 800 cfm
- Electrical Service: 6.0 kW
- Gas Service: 500,000 Btuh



OA-6000 Alpha Prototype

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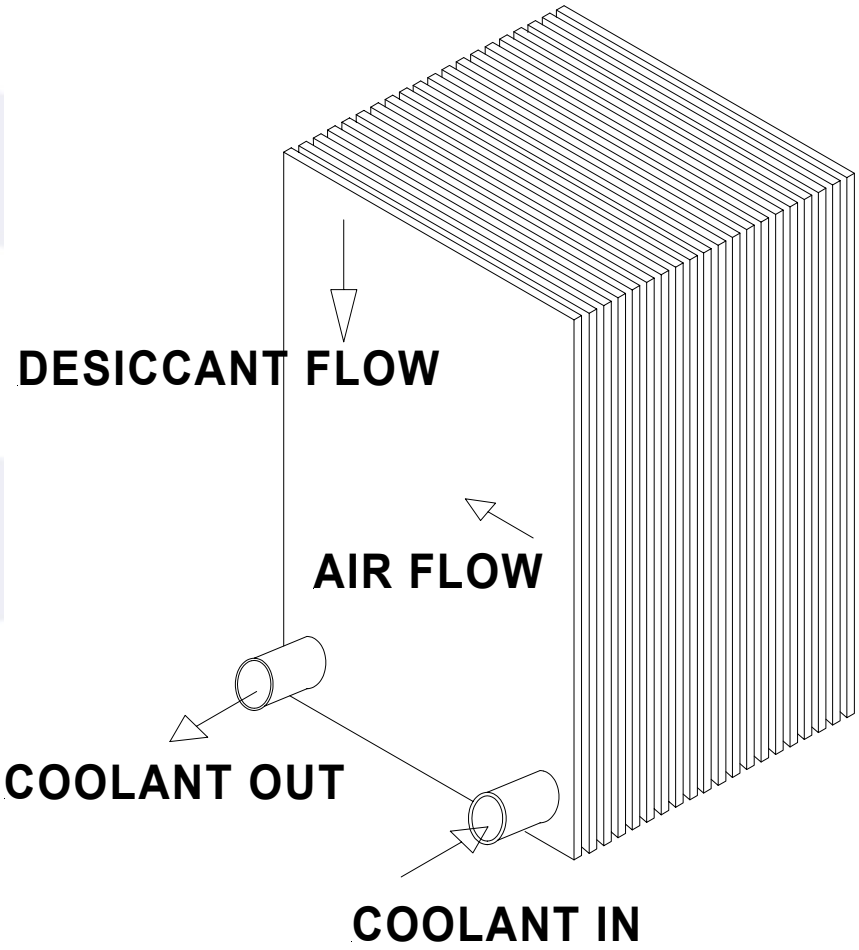
How is Low-Flow Technology Implemented?

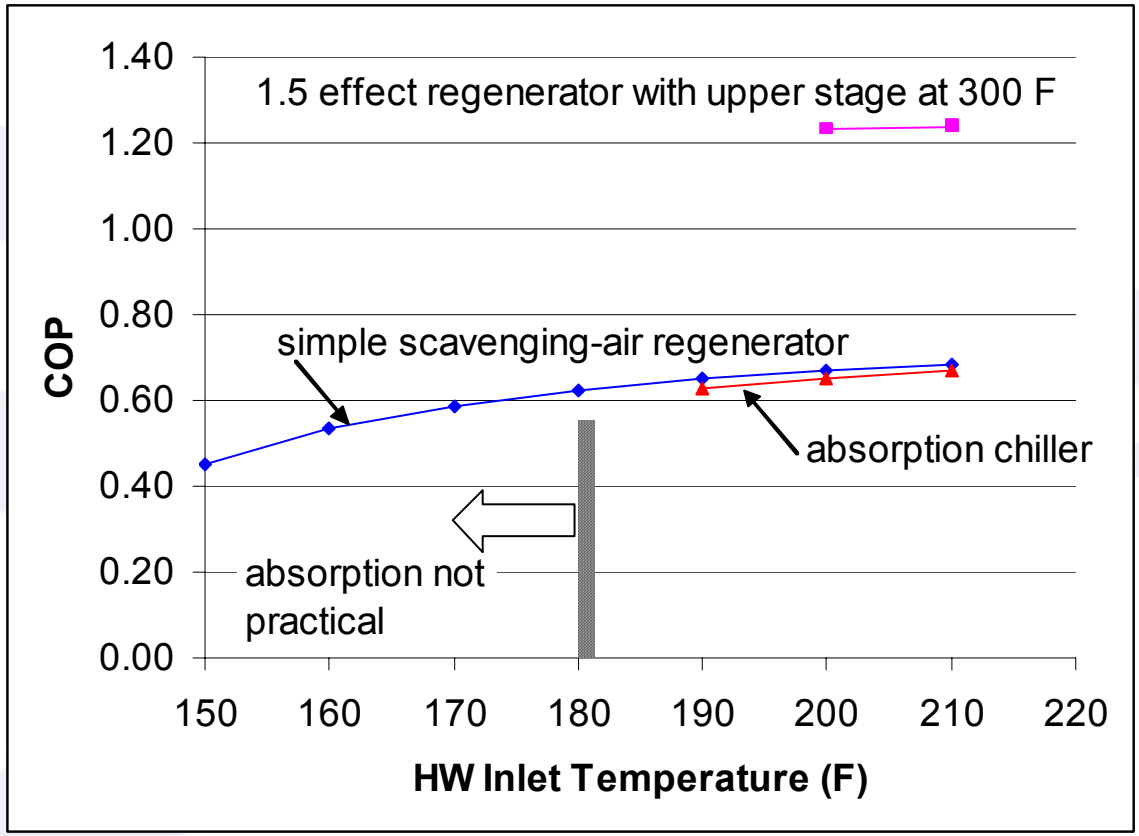


- Water-to-air HX
- Plastic plates
  - Low cost
  - Resist corrosion
- Wick distributes desiccant
- Patent-pending design developed with NREL support
- Performance confirmed by NREL

6,000-cfm Water-Cooled Conditioner

Liquid-Desiccant Systems Can Run on Low Grade Heat

- COP over 0.6 with 180 F hot water
- Excellent match to DE
- Advanced systems with COPs over 1.2



Liquid-Desiccant Systems will offer serious competition to electric cooling/dehumidification

Early markets will be:

- **Where latent cooling has high value**
  - **Ventilation in humid climates (DOAS)**
  - **Control indoor humidity**
- **Where DE heat is available**
- **Where utility rates favor gas over electricity**

Dedicated Outdoor Air Systems are an important application where gas-fired LD systems now can compete

Many manufacturers have recently introduced electric DOASs for ventilation air and high latent loads

- **condenser reheat**
- **air/air heat exchange**
- **enthalpy recovery with solid desiccants**

Liquid Desiccant System will have important size and weight advantages

For 6,000-cfm Outdoor Air System

Condenser Reheat

195” x 96” x 70” ; 6,000 lb

Air/Air Heat Exchanger (6,700 cfm)

118” x 84” x 74” ; 6,020 lb (air handler)

88” x 60” x 69”; 1,150 lb (20 T condenser)

Enthalpy Recovery/Solid Desiccant

293” x 98” x 74”; 11,750 lb (air handler)

88” x 60” x 69”; 1,150 lb (20 T condenser)

Liquid Desiccant System

122” x 80” x 98”; 4,100 lb ship/ 5,600 lb operating

132” x 80” x 77”; (second generation)

Liquid Desiccant System allows downsizing of central AC

	Office Building in the Southeast Full Year Operation (heating costs not included) 3120 ventilated hours $0.08 per kWh $0.80 per therm 80% boiler efficiency								
	DX Tons	Vent Rate cfm	Missed Latent %	Reheat & Regen therms	Comp Power kWh	Recirc Fan kWh	Fan Pump kWh	electric annual kWh	annual cost dollars
DX Base Case	100	6,000	0.01%	2,839	170,725	72,527	19,269	262,521	$23,273
LD Precondition	81	6,000	0.00%	11,099	130,522	60,563	27,351	218,436	$26,354
Advanced LD	81	6,000	0.00%	6,058	130,522	60,563	27,351	218,436	$22,321
LD with DG	81	6,000	0.00%	0	130,522	60,563	27,351	218,436	$17,475

Commercialization Strategy

Key Assumptions

- Successful field demonstrations necessary to attract early sales as well as a manufacturing partner
- Controlled growth until product proves itself
- Sufficient demand from “high value” applications to support initial manufacturing at low volume
- Product can be sold at a profit during early stage of commercialization
- DE and solar applications will be important early sales due to unique characteristics of LD system

Commercialization Strategy

Schedule

- Three field demonstrations starting summer 2004
- Six pre-commercial sales with 2005 delivery; mix of industrial, DE, solar, commercial building applications
- High COP regenerator to be field tested summer 2005
- Modest expansion of production starts following successful 2004 demonstrations
- 20 to 30 units delivered in 2006
- Sales and service partner on board in 2005

Current Status

- **Performance**
  - Zero carryover demonstrated in over 1,000 hours of conditioner operation
  - Latent and sensible cooling verified by NREL
- **Maintenance**
  - No degradation in conditioner performance in over 1,000 hours of operation
  - Schedules for changing filters reasonable but not yet determined

Current Status (continued)

- **Lifetime**
  - No degradation observed in conditioner
  - Materials problems in regenerator now being addressed; long life remains to be proven
- **Selling Price**
  - Prototypes cost about $100 K; $120 K fully instrumented (includes boiler and CT)
  - Early sales at $10 to 14 per cfm
  - At higher production levels, manufacturing cost should be consistent with $5 per cfm selling price

Conclusion: The Future Looks Promising for Liquid Desiccant Systems